Effect of Process Variables on Cr (IV) Removal from Liquid Waste Using Guava Leaf (*Psidium guava)*

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Abstract. The removal of Cr(IV) in aqueous solution by Guava Leaf (Psidium Guajava) as a bio-sorbent was experimentally investigated. The experiment was carried out in a batch stirred reactor at room temperature. The effects of certain parameters, such as concentration of bio-sorbent and contact time, were investigated. The removal increased with contact time and concentration of bio-sorbent. The results showed that the contact time is directly proportional to the sorption capacity and the sorption efficiency. The sorption efficiency of Cr (VI) was highest at 5 grams bio-sorbent, while the sorption capacity of Cr (VI) was highest in bio-sorbent 1 gram under current experimental condition. The optimum removal of Cr (VI) using guava leaves occurred while stirring 30 minutes.
Keywords: Adsorption, bio-sorbent, Cr (VI) removal.

Introduction

The wide use of heavy metals and its compounds by modern industries has resulted in large quantities of this element being discharged into environment. These inorganic micro-pollutants are of considerable concern because they are non-biodegradable, highly toxic and have a probable carcinogenic effect. If directly discharged into the sewage system, their presence decreases the efficiency of the biological treatment (Madoni *et al.*, 1996; Cimino *et al.*, 2000; Mariana *et al.,* 2006).

Among the heavy metals, chromium is one of the most important environmental issues. Most of the chromium is discharged into aqueous waste as a Cr(VI) and Cr(III). A wide range of technologies are available for the removal of Cr(IV) and Cr(III) from wastewater.

Cr (VI) in liquid waste more danger than Cr (III). Removal of Cr (VI) is more difficult compared to Cr (III). Removal of Cr (VI) from liquid waste has been conducted by various researchers for example adsorption process using chemicals as adsorbent. The use of chemicals as adsorbent is not friendly to the environment. Therefore, it needs to look for another alternative adsorbent environmentally friendly. The use of bio-sorbent to absorb heavy metals such as Cr (VI) is very promising because it is friendly to the environment.

A number of research have been used bio-sorbent for treatment of Cr(VI)-containing wastewater. Sudiarta (2009) using seaweed to absorb Cr (III), Aprilia Susanti (2009) utilizing peanut skins as bio-sorbent to absorb reactive dyes Cibacron Red and Ajeng et al (2010) using chitosan from crab shells to absorb copper ions. Sutrasno *et al.* (2008) have conducted research using guava bark to absorb metal ions Cr (VI). The results obtained showed that the efficiency of absorption of Cr (VI) is more than 90% at pH 2. This research uses of a guava leave as bio-sorbent which friendly to the environment. Guava leaf is a waste and has pores that can function as a bio-sorbent. Cr (VI) used in this study is a solution of $K_2Cr_2O_7$.

Materials and Methods

The experiment was carried out by batch process. The Cr(VI) solutions were treated in an experimental system consisting of a flask shaker, a 300 mL erlenmayer. The $K_2Cr_2O_7$ in concentration of 1 ppm (0,03 gram) was mixed with 1000 mL of water in the erlenmayer. A total of 200 mL sample with a concentration of 1 ppm $K_2Cr_2O_7$ incorporated into 250-ml Erlenmeyer flask which already contains the bio-sorbent. Bio-sorbent dosage varied as much as 1 gram, 2 grams, 3 grams, 4 grams, and 5 grams. The content of the erlenmayer was shaken at 350 rpm for varied contact times (5 minutes, 10 minutes, 20 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes and 150 minutes) and then settled for 30 min. The precipitate was separated from the solutions by filtration through Whatman 41 filter paper. The filtrates were analysed for residual Cr(VI) using atomic absorption spectrophotometer (AAS). The experimental conditions are shown in Table 1.

Table 1. Experimental conditions

Parameters	Value
Initial Cr^{6+} concentration [ppm]	1
Bio-sorbent dosage (gram)	1 – 5
Temperature [^{o}C]	Room
Contact time [min]	50 – 150
Precipitation time [min]	30

Results and Discussion

The Cr(VI) removal was studied under different conditions, viz. Bio-sorbent dosage (1-5 gram) contact time (50–150 min)

Effect of contact time and bio-sorbent dosage on absorption efficiency of Cr(VI)

To study the effect of contact time and bio-sorbent dosage on sorption efficiency of Cr(VI), the experiments were carried out by varying contact time between bio-sorbent and absorbat from 50 to 150 minutes and bio-sorbent dosages from 1 to 5 gram. The result was plotted in Figure 1.

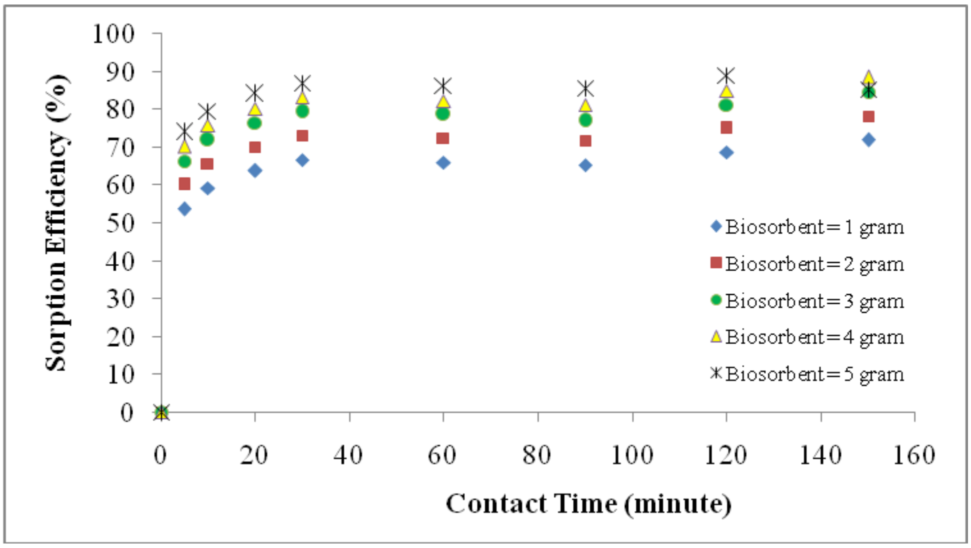

Figure 1. Contact time vs. sorption efficiency by various dosage of bio-sorbent

Determination of the contact time was made to determine the effect of the time on the efficiency of absorption. It aims to find out the time in which the optimum adsorption process takes place. It shows that the sorption efficiency increased with incresed in contact time between adsorbent with adsorbate. This result agrees with the experimental results obtained by Ajeng (2010) for removal chrome and copper using chitosan from crab shells. Figure 1 shows that the sorption efficiency increased with increased in dosage of bio-sorbent. At a bio-sorbent dosage of 1 gram and contact time 30 minutes, the sorption efficiency of Cr (VI) was 66.70%, while the bio-sorbent dosage of 2, 3, 4, and 5 grams for 30 minutes, the sorption efficiency of Cr (VI) are 73.05; 79.39; 83.22, and 87.05%, respectively. This result agrees with the experimental results obtained by Soemargono, *et al.* (2008). Soemargono reported that the contact surface area between the adsorbent with adsorbate increased with increased in bio-sorbent dosage, thus increasing the sorption of the adsorbate. Figure 1 also explained that the contact time and dosage of bio-sorbent is directly proportional to the sorption efficiency. The bio-sorbent dosage of 5 grams and contact time 5, 10, 20, 30, 60, 90, 120, and 150 min, absorption efficiency obtained for 74.10; 79.65; 84.14; 87.05; 86 , 39; 85.73; 89.03, and 85.33%, respectively.

At the beginning of the contact process, the sorption efficiency takes place very rapidly until 30 minutes and Cr (VI) adsorbed on the rise. However, once in contact for 60 to 150 minute the sorption efficiency tend to be constant. According to Muktamar, *et al.* (2004), the longer contact time caused the pores of the adsorbent to be fully charged initially empty, causing the adsorbate quantity absorbed by the bio-sorbent at a certain time will begin to enter a state of static or with a relatively low increase. Based on the above commentary, it can be concluded that the optimum sorption process occurs at the contact time of 30 minutes.

Effect of contact time and bio-sorbent dosage on Absorption Capacity of Cr(VI)

To study the effect of contact time and bio-sorbent dosage on sorption capacity of Cr(VI), the experiments were carried out by varying contact time between bio-sorbent and absorbat from 50 to 150 minutes and bio-sorbent dosages from 1 to 5 gram. The result was plotted in Figure 2.

Sorption capacity is the amount of metal ions adsorbed per sorbent mass (Nurhayati, 2009). The contact time is very influential on the sorption capacity. This is because the longer of the time contacting, more metal is absorbed to the bio-sorbent (Ajeng, 2010). Figure 2 shows the effect of contact time on the sorption capacity of Cr (VI). At the contact time of 5, 10, 20, 30, 60, 90, 120, and 150 minutes and a bio-sorbent dosage of 1 gram obtained sorption capacity are 0.1075; 0.1186; 0.1276; 0.1334; 0,1321; 0.1308; 0.1374, and 0.1440 mg/g, respectively.

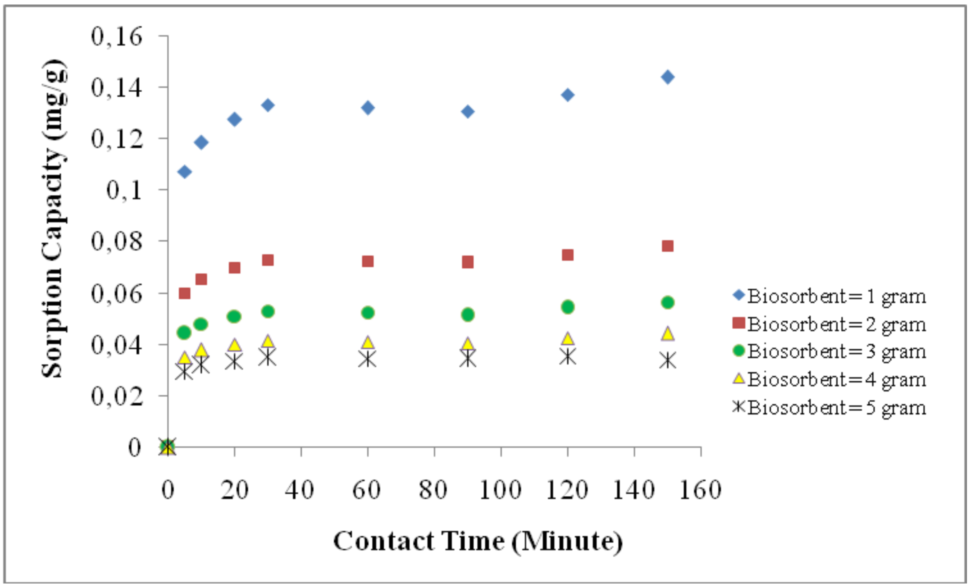

Figure 2. Contact time vs. sorption capacity by various dosage of bio-sorbent.

Figure 2 also shows the effect of bio-sorbent dose on the absorption capacity of Cr (VI). At the bio-sorbent dose of 1, 2, 3, 4, and 5 grams and contact time for 150 minutes, the sorption capacities are 0.1440; 0.0783; 0.0565; 0.0443, and 0.0341 mg/g, respectively. Based on the above data, it can be concluded that more the bio-sorbent used the absorption capacity will be smaller. This is because more bio-sorbent are used, the pore space available in the adsorbent will also be increased. Therefore, if the bio-sorbent is used to absorb the adsorbate with the same concentration, the bio-sorption capacity will be smaller.

Conclusions

From the present study, it can be concluded that the contact time is directly proportional to the sorption efficiency and sorption capacity. Bio-sorbent dose is directly proportional to the sorption efficiency and inversely proportional to the capacity. Removal for Cr (VI) using guava leaves reached optimum at contact time of 30 minutes.

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